Universal Journal of Environmental Research and Technology
 eISSN 2249 0256
Available Online at: **www.environmentaljournal.org**
Volume 3, Issue 2: 181-189

Open Access **Research Article**

Variation in Phytoplankton Diversity and Its Relationship with Abiotic Environment of a Temple Pond in Birpur (J&K) India

Aarti Devi[1] and Neha Antal[2]

[1]Research Scholar, Department of Zoology, University of Jammu, Jammu, J&K, India-180006
[2]Research Scholar, Department of Zoology, University of Jammu, Jammu, J&K, India-180006

Corresponding author:aartisharma455@gmail.com, nehaantal21@gmail.com

Abstract:

Investigations were carried out on the diversity of phytoplankton in relation to physico-chemical parameters with respect to water quality status of a subtropical pond, "Datte da Talab in J&K. The physico-chemical parameters showed well-marked seasonal variations. A total of 21 genera belonging to three different groups (Bacillariophyceae, Chlorophyceae and Cyanophyceae) were recorded during the study period with maxima in winter season and minima in summer season. Qualitatively and quantitatively Bacillariophyceae dominated all other classes followed by Chlorophyceae and Cyanophyceae. No apparent differences were found in phytoplankton composition at all the sampling sites. Phytoplankton community when correlated with physico-chemical parameters indicated that the distribution and density of phytoplankton species was influenced by physical and chemical factors of the pond environment. Phytoplankton showed significant correlation with certain abiotic parameters such as water and air temperature, phosphates, carbonates and chlorides. The various kinds of indices such as Margalef's index, Menhinck's index, Simpson index, Shannon-Wiener index and Equitability index were used to support the data.

Keywords: Correlation, diversity index, physico-chemical parameters and phytoplankton.

1.0 Introduction

Standing at the bottom level of the food chain, phytoplanktons bear a significant importance in respect of their role in aquatic ecosystems and their relations with other organisms at top levels. Phytoplanktons are the major primary producers in many aquatic ecosystems and are important food source for other organisms as reported by Sukumaran *et al.* (2008) in his studies on species composition and diversity of phytoplankton of Pechiparai dam. Phytoplanktons not only serve as food for aquatic animals, but also play a crucial role by maintaining the biological balance and quality of water as revealed by Pandey *et al.* (1998) while studying the algal flora of Fatehsagar Lake. Various physico-chemical factors like pH, DO, alkalinity and the dissolved nutrients affect the phytoplanktonic production. Plankton diversity quickly responds to change in the environment of aquatic system, particularly in relation to nutrients. In addition to this, these play a major role in biogeochemical cycles of many important elements such as carbon cycle, nitrification and methanogenesis. These cycles bring about primary production and recycling.

Planktons are very sensitive to the environment they live in and any alteration in the environment leads to the change in the plankton communities in terms of tolerance, abundance, diversity and dominance in the habitat. They react fast to the pollution in the aquatic environment. Therefore, plankton population observation may be used as a reliable tool for biomonitoring studies to assess the pollution status of aquatic bodies Mathivanan and Jayakumar (1995). Several phytoplanktonic species have served as bioindicators. Vareethiah and Haniffa (1998) and Bianchi *et al.* (2003) studied phytoplankton as bioindicators. Tiwari and Chauhan (2006) investigated seasonal phytoplanktonic diversity of Kitham Lake of Agra. Phytoplankton are the diagnostic tools in assessing water quality and hydrological status as suggested by Nwankwo (2004) while studying Nigerian coastal waters. The present study was conducted with an aim to investigate the current limnological conditions in the pond so that the water quality status of this subtropical pond can be determined as this pond water is used by the local people and pilgrims for bathing and drinking purposes.

2.0 Material and Methods

2.1 Study Area and Stations

The temple pond, "Datte da Talab" is located in Birpur region of Samba District of J&K state, India. This is the oldest pond in this region having great religious significance. It lies between 32°39'50" N (latitude) and 74°57'10" E (longitude) and at an elevation of 423 m above the mean sea level. It has a rectangular shape having a length of 25.2 metres and width of 21.60 metres and 45 cms. With a view to have an overall idea of the various physico-chemical and biological characteristics of this pond, four stations have been established on the littoral zones of the pond. The stations were named as S-I, S-II, S-III and S-IV **(Fig-1-4)**. Station-I have been separated from the rest of the pond by a cemented wall and is "Bathing Ghat" for females.

2.2 Methodology

For studying physico-chemical parameters of water, monthly sampling was done from May 2011 to April 2012. Water samples were collected in plastic water samplers of 2 litres capacity. Measurement of parameters like air temperature, water temperature, pH, DO, FCO_2, CO_3^{2-}, HCO^{3-}, Cl^-, Ca^{2+} and Mg^{2+} was done on the spot while phosphates, sulphates and nitrates were determined within two hours of water sample collection in the laboratory by following the standard methodology of Adoni (1985) and A.P.H.A (1985).

The plankton samples were collected by filtering 20 litres of water through the standard plankton net (25 mesh bolting silk). Finally the volume of planktonic concentrate was adjusted to 20 ml and preserved by adding 5% formalin. Phytoplankton species identification was done with the help of standard references Whipple and Pasker (1902). The quantitative analysis of planktonic organisms was carried out using Sedgwick Rafter plankton counting cell A.P.H.A (1985). The number of plankton per ml of the concentrate was calculated by using the formula:

$$\text{Number/ml} = \frac{C \times 1000}{A \times D \times F} m^3$$

Where,
C= no. of organisms counted
A= area of the field
D= depth of the field (mm)
(S-R depth of = 1mm)
F=no. of fields counted

Statistical analysis of phytoplankton population was done using indices such as Margalef's index, Menhinck's index, Simpson index, Shannon-Wiener index and Equitability index.

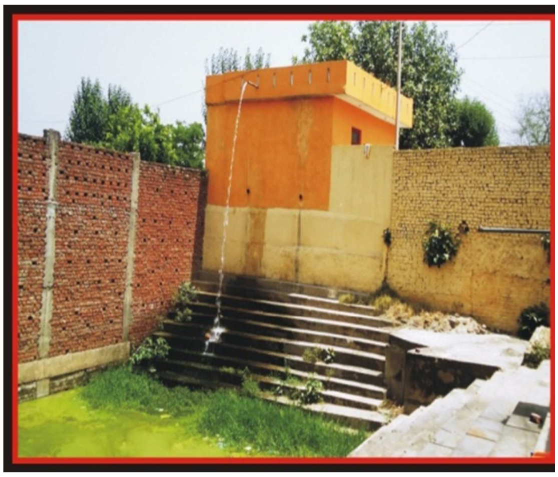

Fig 1: View of pond "Datte da Talab" showing Station-I

Fig 2: View of pond "Datte da Talab" showing Station-II

Fig 3: View of pond "Datte da Talab" showing Station-III

Fig 4: View of pond "Datte da Talab" showing Station-IV

3.0 Results and Discussions

Physico-chemical parameters are the important constituents of the aquatic system as they reflect the water quality of aquatic ecosystem. Seasonal variations in the physico-chemical parameters in pond, "Datte da Talab" were studied during the study period of May 2011 to April 2012 and are shown in **Table-1.** Mean values of transparency ranged from 32.10 cm (January) to 56.75 cm (August). Higher values of transparency were recorded throughout the year because of settling of suspended organic matter. Water temperature varied in accordance with the air temperature and it ranged from 11.63°C (December) to 33.0°C (May). Water temperature closely follows air temperature as suggested by Kour and Joshi (2006) during their studies on physico-chemical parameters of River Ganga in and around Haridwar. pH of the water remained alkaline throughout the study period and ranged between 7.65 (November) to 9.40 (February). The higher value of pH in winter season is attributed to decreased temperature and high values of DO and carbonate Pandey *et al*. (1998).

Dissolved oxygen varied from 1.18 mg/l (July) to 11.3 mg/l (February) and it showed higher value in winter season and low value in summer season (Jemi and Balasingh, 2011 and Sahni and Yadav, 2012). FCO_2 recorded its presence in some winter months (November and January) which may be associated with low temperature, decreased water level and overcastting of sky with the clouds (Sawhney, 2008). Presence of free carbon dioxide during winter has been reported by Chandrakiran (2011) and Bangotra (2012). Carbonates showed their absence in November and January and this is due to the presence of FCO_2 during this period. An increase in the values of bicarbonates was recorded in summer and monsoon seasons. Chloride is an important indicator of organic pollution Khare*et et al*. (2007). Its concentration varied from 11.98 mg/l (October) to 52.70 mg/l (May). The maximum (40.90 mg/l) and minimum (16.43 mg/l) values of calcium were recorded in the months of November and February respectively. Magnesium concentration varied from 16.53 mg/l (February) to 42.28 mg/l (October). The major limiting nutrients for phytoplankton are nitrogen in the form of nitrate, nitrite and phosphate. Suthers and Rissik (2009) suggested that Nitrogen tends to be the limiting nutrient in marine systems while phosphate is the limiting nutrient in the fresh water systems. These two nutrients are necessary for the construction of cell membranes and proteins such as enzymes. Phosphate varied from 0.0 (Sep., Nov., Jan. & Feb.) to 0.0564 mg/l (May). A very low value of phosphates was recorded at all the stations. Lower values in phosphates during winter and spring periods resulted from its utilization by the algal planktons for photosynthesis Gonzalves (1946) and low water circulation Anhwange *et al*. (2012). Presence of nitrates in water indicates the final stage of mineralization and nitrates varied from 0.572503 mg/l (December) to 0.57283 mg/l (July).

Table 1: **Mean variations in the physico-chemical parameters of four stations during May 2011 to April 2012.**

Parameters	Unit	Station-I	Station-II	Station-III	Station-IV
Depth	Cm	53.93±11.75	41.025±5.16	44.65±7.14	43.83±7.78
Transparency	Cm	51.53±11.06	38.98±5.55	46.33±11.74	42.57±7.34
Air temp.	°C	27.73±7.60	25.93±8.10	27.27±7.47	26.95±7.22
Water temp.	°C	24.75±7.58	24.46±6.98	25.48±7.71	24.42±7.97
pH	-	8.24±0.45	8.56±0.46	8.42±0.57	8.39±0.46
FCO2	mg/l	2.33±4.07	0.5±1.66	0.5±1.66	0.98±2.36
Carbonates	mg/l	31.15±25.52	35.3±19.33	36.05±19.80	35.6±23.76
Bicarbonates	mg/l	340.35±82.90	324.66±19.33	313.38±76.60	317.73±75.81
DO	mg/l	4.21±2.98	5.35±3.98	5.37±3.84	5.14±3.49
Chloride	mg/l	22.29±12.80	21.87±10.34	20.86±10.54	21.33±10.35
Calcium	mg/l	30.55±7.56	27.07±7.13	23.96±5.82	25.40±6.61
Magnesium	mg/l	28.35±6.67	27.78±8.51	27.21±8.54	26.29±7.45
Nitrate	mg/l	0.572666±0.000223	0.572553±0.000112	0.572636±0.000234	0.572578±0.000109
Phosphate	mg/l	0.013981±0.018061	0.009235±0.011649	0.011594±0.01287	0.028794±0.039455

Table 2: **Phytoplankton species occurrence during May 2011 to April 2012 in Datte da Talab, Pond.**

	Summer				**Monsoon**				**Winter**			
Bacillariophyceae	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
Fragilaria sp.	+	+	+	+	+	+	+	+	+	+	+	+
Stauroneis sp.	+	-	-	-	+	-	+	+	+	+	+	+
Frustulia sp.	+	+	-	+	+	+	+	+	+	+	+	+
Pinnularia sp.	+	-	-	+	+	+	-	+	+	+	+	+
Cymbella sp.	+	-	+	-	+	+	+	+	+	+	+	+
Nitzchia sp.	-	-	-	-	+	+	-	-	-	+	+	+
Synedra sp.	+	+	-	+	+	+	+	+	+	+	+	+
Navicula sp.	+	+	+	+	+	+	+	+	+	+	+	+
Diatoma sp.	+	+	-	-	-	+	+	+	+	+	+	+
Gomphonema sp.	-	-	-	-	+	+	+	+	+	+	+	+
Chlorophyceae												
Ankistrodesmus sp.	+	+	-	-	+	+	+	+	+	+	+	+
Scenedesmus sp.	+	+	+	+	+	-	+	+	+	+	+	+
Cosmarium sp.	+	-	+	-	-	+	+	+	+	+	+	+
Microspora sp.	+	+	-	+	+	+	+	+	+	+	+	+
Spirogyra sp.	+	+	+	-	+	+	+	+	+	+	+	+
Oedogonium sp.	+	+	+	-	+	+	+	+	+	+	+	+
Volvox sp.	+	-	+	-	-	-	+	+	-	-	+	+
Selanastrum sp.	+	-	-	-	-	+	+	+	+	+	+	+
Cyanophyceae												
Oscillatoria sp.	+	+	+	+	+	+	+	+	+	-	+	-
Spirulina sp.	+	-	+	+	+	+	+	-	-	+	+	+
Merismopedia sp.	+	+	+	-	+	+	+	+	-	+	+	-

Table 3: **Monthly variation in phytoplankton (no./l) of water at four Stations from May 2011 to April 2012.**

	Station	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Bacillariophyceae	I	2.1	7.9	45.0	30.8	31.6	24.6	65.2	77.6	83.7	77.7	27.3	16.2
	II	5.1	2.7	26.6	33.0	31.5	35.5	35.5	72.6	64.8	76.5	24.9	18.0
	III	4.8	1.8	1.8	28.2	13.2	18.6	26.1	68.4	79.2	62.1	23.5	13.5
	IV	1.2	1.5	15.6	14.4	18.9	16.8	34.9	56.1	52.8	55.2	12.0	12.0
	Mean	3.3	3.48	22.5	26.6	23.8	24.6	40.42	68.68	70.13	67.88	21.93	14.93
Chlorophyceae	I	3.0	1.5	3.6	9.0	10.8	24.0	41.2	43.8	47.7	40.2	18.6	9.9
	II	1.5	0.6	1.2	4.2	3.3	19.2	30.6	51.0	50.1	39.9	21.0	7.5
	III	0.6	0.6	1.8	7.8	11.7	11.4	11.4	30.3	31.2	32.4	20.1	6.9
	IV	0.0	1.2	0.0	3.9	10.2	18.0	30.0	24.9	26.4	20.7	9.3	7.5
	Mean	1.28	0.98	1.65	6.23	9.0	18.15	28.3	37.5	38.85	33.3	17.25	7.95
Cyanophyceae	I	5.1	10.2	10.8	13.2	5.7	2.7	1.8	2.1	6.0	0.6	1.8	0.0
	II	15.0	10.5	12.6	8.7	12.9	7.5	0.3	1.2	4.8	0.6	5.4	6.6
	III	18.3	16.2	16.5	12.0	1.2	4.2	1.5	2.1	2.4	0.0	0.0	0.0
	IV	6.9	13.5	11.7	5.4	9.6	5.4	3.6	0.6	0.3	0.6	1.2	3.6
	Mean	11.33	12.6	12.9	9.83	7.35	4.95	1.8	1.5	3.38	0.45	2.1	2.55

Table 4: Correlation between physico-chemical parameters and various phytoplankton groups.

Parameters	Bacillariophyceae	Chlorophyceae	Cyanophyceae
Depth	0.13	-0.20	-0.20
Transparency	-0.02	-0.11	-0.06
Air temp.	-0.92	-0.93	0.67
Water temp.	-0.90	-0.97	0.73
pH	0.33	0.21	-0.19
Carbonates	-0.44	-0.68	0.78
Bicarbonates	0.35	0.33	0.07
DO	0.62	0.65	-0.44
Chloride	0.58	-0.58	0.54
Calcium	0.13	0.25	-0.16
Magnesium	-0.24	0.42	-0.24
Phosphate	-0.65	-0.72	0.77
Nitrate	-0.41	-0.50	0.56
FCO_2	0.31	0.45	-0.41

Table 5: Annual variations of phytoplanktons and biodiversity indices in different stations.

Diversity indices	**Index**	**S-I**	**S-II**	**S-III**	**S-IV**
Species richness	(No.)	21	21	21	21
	R_1	2.25	2.15	2.24	2.14
	R_2	0.25	0.24	0.29	0.28
Species diversity	I	0.16	0.18	0.17	0.20
	H	2.73	2.56	2.64	2.49
Species evenness	E	0.90	0.86	0.88	0.84
Dominance	D	0.84	0.81	0.83	0.79

N_0 = No. of species, R1 = Margalef"s index, R2 = Menhinick index, I= Simpson index, H= Shannon-Wiener index, E= Equitability index and D= Dominance index

3.1 Qualitative analysis of phytoplankton

During the present study period extending from May 2011 to April 2012, the phytoplanktonic population in case of Datte da Talab, pond was found to be comprised of 21 genera belonging to different classes. The class Bacillariophyceae was dominant among all other classes having maximum diversity, represented by 10 genera, followed by class Chlorophyceae, represented by 8 genera and class Cyanophyceae having least diversity, represented by 3 genera only (Table 2). Similar pattern of dominance of different classes among phytoplankton has been observed by Zuber (2007) and Verma (2009).

The class Bacillariophyceae was represented by *Fragilaria* sp., *Stauroneis* sp., *Frustulia* sp., *Pinnularia* sp., *Cymbella* sp., *Nitzchia* sp., *Synedra* sp., *Diatoma* sp., and *Gomphonema sp.* Station wise distribution of class Bacillariophyceae highlighted the absence of *Diatoma* sp., at Station -II and Station-IV. From class Chlorophyceae, the phytoplanktonic members were represented by *Ankistrodesmus* sp., *Scenedesmus* sp., *Cosmarium* sp., *Volvox* sp., *Spirogyra* sp., Oedogonium sp., *Microspora* sp., *and Selenastrum sp.* whereas the class Cyanophyceae was represented by three genera only viz. *Oscillatoria sp., Spirulina* sp., *and Merismopedia* sp. All the members of class Chlorophyceae and Cyanophyceae were found to inhabit all studied stations of the water body.

Inquisitive studies also revealed the presence of pollution indicator species viz. *Oscillatoria* sp. and *Spirulina* sp., among Cyanophyceae, *Ankistrodesmus* sp., and *Scenedesmus* sp. among Chlorophyceae, *Navicula* sp., *Nitzchia* sp., and *Synedra* sp. among Bacillariophyceae. The very presence of these pollution indicator species implies that the nature of anthropogenic stress and pollution threat arising in Datte da Talab, pond. Such species have already been identified as pollution indicator species by Rai (1980), Chandermohan (1993), Zuber (2007), Sawhney (2008) and Verma (2009).

3.2 Quantitative Analysis of Phytoplankton

Quantitative analysis of phytoplankton in this pond revealed the dominance of Bacillariophyceae, Chlorophyceae and Cyanophyceae. The class Bacillariophyceae contributed 47.61% to the total phytoplanktonic population whereas class Chlorophyceae contributed 38.09% and Cyanophyceae contributed 14.28% to the total phytoplanktonic population. Chandermohan (1993), Sawhney (2008), Verma (2009), Rajagopal *et al.* (2010) and Kensa (2011) have also demonstrated the similar dominance among phytoplankton in their respective lentic water bodies.

Seasonal variations among different classes of algae were found to be closely related to the change in physico-chemical conditions of the water. Thus, the change in water chemistry makes the water environment conducive for some species while for some others, it becomes non-conducive. Such an interrelationship between physico-chemical parameters and phytoplankton has been reported by Rajagopal *et al.* (2010) and Kensa (2011). Seasonal fluctuations of diatoms registered bimodal peak in winter (January) and monsoon (August) and decline in summer season (May-June). Singh and Swarup (1979) and Sawhney (2008) also observed that diatom number was greater during early summer, post monsoon and winter and lowest during late summer, which is in accordance with the present findings.

The bimodal peak of diatoms has been noticed in winter and monsoon seasons. Higher level of DO, decreased FCO_2, Optimum temperature, alkaline pH and nutrient concentration (nitrates and phosphates) have favoured the growth and multiplication of diatoms during these months while the increased oxidizable organic matter and inorganic salts (nitrates and phosphates) brought with the surface run-off due to monsoon rains together with the presence of abundant macrophytes have favoured their abundance in monsoon months. The present findings are in accordance with the findings of Zafar (1964), Gochhait (1991) and Verma (2009). It was also observed that in case of Datte da Talab, pond high calcium facilitated the growth of diatoms during monsoon and winter as suggested by Singh and Swarup (1979).

Chlorophyceae or green algae comprise an important phytoplanktonic group both in terms of abundance and frequently occurrence. Seasonal variations in members of family Chlorophyceae showed maxima in winter (January, February) and minima in summer months (June) at all the study stations. During summers the chlorophycean count remained low due to grazing effect of zooplankton and increased fish-feeding associated with high temperature. Such an inverse relationship between phyto and zooplankton has been reported by ChanderMohan (1993). High Chlorophycean count registered during winter months may be due to high DO and bicarbonate level prevailing during these periods, which favours its quick growth. These studies are also supported by the findings of Welch (1952) who also observed direct relationship of bicarbonates with Chlorophyceae.

Cyanophyceae, the least represented among phytoplankton was observed to be present throughout the year. Peak in Cyanophyceae has been observed during monsoon and summer seasons. The increased temperature during these periods seems to play a very important role in the periodicity of Cyanophyceae The highest number of Cyanophycean count has been recorded in monsoon which could be attributed to the high water temperature and low oxygen content. Hutchinson (1957), Chakraborty *et al.* (1959), Lund (1965), Munawar (1974), Singh and Swarup (1979), Sharma (1989), ChanderMohan (1993) and Sawhney (2008). Also high organic matter and low dissolved oxygen content are the favourable attributes for the better growth of Cyanophyceae. Low temperature and reduced photoperiod during winter season seems to be responsible for winter minima of Cyanophyceae. Similar reports have been given by Munawar (1970), Singh and Swarup (1979) and ChanderMohan (1993).

To study the relative effect of some environmental factors, correlation analysis was made between phytoplankton and physico-chemical parameters (**Table-4)**. The plankton showed significant relation with water and air temperature, phosphates, carbonates and chlorides. The temperature is significantly and negatively correlated with Bacillariophyceae and Chlorophyceae whereas it was positively correlated with Chlorophyceae. Bacillariophyceae was positively correlated with DO and Chloride and negatively correlated with water temperature and phosphates. Chlorophyceae was negatively correlated with water temperature, carbonates and chlorides. A positive correlation occurred between water temperature and Cyanophyceae. Phytoplankton had a negative correlation with phosphates due to high rate of phytoplankton phosphorus uptake at low concentrations throughout the study period at all the study stations (Dogipatri et al., 2013). Various indices such as Shannon- Wiener (H') index, Simpson index (I), Margalef"s index (R_1) and Equitability index (E) were used to analyse species diversity, richness and evenness respectively. The analysed data revealed the maximum species diversity in terms of Shannon-Wiener index (H' =2.73) at Station-I whereas minimum value of this was recorded at station-I. The maximum (R_1=2.25) and minimum (R_2=2.14) values of species richness were recorded at Station-I and Station-IV respectively. Value of evenness (E) was higher at Station-I and lower at Station-IV **(Table-5)**.

4.0 Conclusion:

1. The abundance and diversity of phytoplankton of pond water was influenced by many physico-chemical factors and also depends upon the interactions among biological factors.
2. A higher value of species diversity and species richness at all the sites depicts the favourable conditions in terms of physico-chemical conditions.
3. Although phytoplankton exists under a wide range of environmental conditions, yet many species are limited by DO, temperature and other physico-chemical factors.
4. The presence of different pollution indicator species clearly indicates that the pond is approaching towards organic pollution and it is in the initial stages of eutrophication.

5.0 Acknowledgement:

Authors are thankful to the Head, Department of Zoology for providing encouragement and necessary laboratory facilities.

References:

1) Adoni, A.D. (1985): Workbook on limnology: Pratibha Publishers, C-10, Gour Nagar, Sagar – 470003, India. 216pp.

2) Anhwange, B.A., Agbaji, E.B. and Gimba, E.C. (2012): Impact assessment of human activities and seasonal variation on River Benue, within Makurdi Metropolis. *International Journal of Science and Technology,* 2(5): 245-253.

3) APHA (1985): Standard methods for Examination of Water and Waste Water, 16th Ed. *American Public Health Association*, Washington D.C.

4) Bangotra, K (2012): Diversity of macrobenthic invertebrates assosicated with Macrophytes in lotic and lentic water bodies of Jammu. M. Phil Dissertation, University of Jammu, Jammu.

5) Bianchi, F., Acri, F., Aubry, F.B., Berton, A., Boldrin, A., Camatti, E., Cassin, D. and Comaschi, A. (2003): Can plankton communities be considered as bioindicators of water quality in the lagoon of Venice? *Mar. Pollut. Bull*., 46: 964-971.

6) Chakraborty, R.D., Roy. P. and Singh S.B. (1959): A quantitative study of plankton and physico-chemical condition of river Jamuna at Allahabad in 1945 to 1959. *Indian Journal of Fisheries*, 6(10): 186-203.

7) Chandrakiran (2011): Impact of sediment characteristics on the benthic communities of Lake Mansar. Ph.D Thesis, University of Jammu, Jammu.

8) ChanderMohan (1993): Limnology of Lake Mansar with Particular reference to primary producers. Ph.D. Thesis, University of Jammu, Jammu.

9) Dogipatri, A. and Chakravarty, M.S. (2013): Study on distribution and diversity of phytoplankton in relation to physico-chemical parameters in Bhavanapadu creek, Andhrapradesh, India. *International Journal of Basics and Applied Sciences.*

10) Gochhait, B.C. (1991): Studies on LImnological factors of river Buddhabalanga at Baripada (Orissa) Ph.D. thesis, Utkal University.

11) Gonzalves, E.A. and Joshi, D.B. (1946): Freshwater algae near Bombay. *Bombay Nat. Hist. Soc.,* 46 (1): 154-176.

12) Hutchinson, G.E. (1957): A treatise on Limnology Vol. I. Geography, Physics and Chemistry. John Sons, Inc. New York.

13) Jemi, J.R. and BalaSingh, G.S.R. (2011): Studies on physico-chemical characteristics of Freshwater temple ponds in Kanyakumari district (South Tamil Nadu). *International Journal of Geology, Earth and Environmental Sciences*,1 (1): 59-62.

14) Kensa, M.V. (2011): Interrelationship between physico-chemical parameters and phytoplankton diversity of two perennial ponds of Kulasekharam area, Kanyakumari district, Tamil Nadu. *Plant Science Feed*, 1(8): 147-154.

15) Khare, S.L., Paul, S.R. and Dubey, A. (2007): A study of water quality of Khomph – Niwau Lake at Chhatarpur, M.P. *Nat. Env. And Poll. Tech.*, 6 (3): 539-540.

16) Kour, S and Joshi, B.D. (2006): seasonal variation in some physico-chemical parameters of river Ganga in and around Haridwar. *Hin. J. Env. Zool*., 17(1): 45-55.

17) Lund, J.W.G. (1965): The ecology of fresh water plankton. *Biol, Rev.*, 40: 231-239.

18) Mathivanam, V. and Jayakumar, S. (1995): The studies on plankton fluctuation in a reservoir of Annamalainagar. *Proceedings of the national symposium on recent trends in Indian wildlife research,* AVC College, Nayiladuthurai, Tamil Nadu, India.

19) Munawar, M. (1970)**:** Limnology studies in fresh water ponds of Hyderabad, India. I. The biotope, *Hydrobiol.,* 25(1): 127-162.

20) Munawar, M. (1974): Limnological studies in fresh water ponds of Hyderabad, India. *Hydrobiol.*, 44(1): 13-27.

21) Nwankwo, D.T. (2004): Studies on the environmental preference of blue green algae (Cyanophyta) in Nigeria coastal waters. *The Nigeria Environmental SocietyJournal*, 2(1): 44-51.

22) Pandey, B. N., Mishra, A.K., Das, P.K.L. and Jha, A.K. (1993): Physico-chemical characteristics of swamps of Libri river, Purnia (Bihar). *Acts. Ecol*., 15(2): 98-102.

23) Pandey, Ushapandey, Tyagi, H. R. and Rai, N. (1998): Algal flora and physico-chemical environment of FatehSagar lake. *Phykos.*, 37(187): 29-30.

24) Pennak, R.W. (1968): Field and experimental limnology of three Colorado mountain lakes. *Ecology*, 19(3): 505-520.

25) Rai, L.C. (1980): Ecological studies of algal communities of the Ganges river at Varanasi. *Indian J. Ecol.*, 5(1): 1-6.

26) Rajashekhar, M. Vijaykumar, K. and Zeba, P. (2010): Seasonal variations of zooplankton community in freshwater reservoir Gulbarga District, Karnataka, South India. *International Journal of Systems in Biology*, 2(1): 6-11.

27) Sahni, K. and Yadav, S. (2012): Seasonal variations in physico-chemical parameters of Bharawas pond Rewari, Haryana. *Asian J. Exp. Sci*., 26(1): 61-64.

28) Sawhney, N. (2008): Biodiversity of river Tawi in the vicinity of Jammu City. Ph.D. Thesis, University of Jammu, Jammu.

29) Sharma, G. (1989): Impact of littoral flora on Renuka and Rewalsar lakes of Himachal Pradesh. Ph.D. Thesis, Himachal Pradesh University, Shimla.

30) Singh, S.R. and Swarup, K. (1979). Limnological studies of Surahalake (Ballia) II. The periodicity of zooplankton. *J. Indian Bot. Soc*., 58: 319-329.

31) Sukumaran, M., Brintha, M. and Mathavanpillai, M. (2008): Species composition and diversity of phytoplankton of Pechiparai dam. *India. J. of Theor. and Expl. Bio.*, 4(4): 157-161.

32) Suthers, I.M and Rissik, D.A (2009). Guide to their ecology and monitoring for water quality. 2nd edition. CSIRO Publishing, Collingwood Victoria, 272pp.

33) Tiwari, A. and Chauhan, S.V.S. (2006): Seasonal phytoplanktoxic diversity of Kitham

Lake, Agra. *Journal of Environmental Biology*, 27(1): 35-38.

34) Vareethiah, K. and Haniffa, M.A. (1998): Phytoplankton pollution indicators of coir retting. *J. Environ. Pollut.*, 3**:** 117-122.

35) Welch, P.S. (1952): Limnology. Second Edition. McGraw Hill, Book Co. New York and London.

36) Whipple, G.C. and Pasker, H.N. (1902): On the amount of oxygen and carbonic acid dissolved in natural water and effect of these gases upon the occurrence of microscopic organism. *Trans. American. Micros. Soc.*, 23: 103-144**.**

37) Zafar, A.R. (1964): On the ecology of algae in certain fish ponds of Hyderabad, India. I. Physico-chemical complex. *Hydrobiol.*, 23: 176-196.

38) Zuber, S.M. (2007): Ecology and Economic valuation of Lake Mansar, Jammu. Ph.D. Thesis, University of Jammu, Jammu.